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Design and Simulation of Meander Line Antenna for RFID Passive Tag

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Abstract: Meandering is one of the methods in order to reduce the size of the antenna. By meandering we can reduce the size of the antenna by about 70%. The meander line antenna is designed using empirical relations and simulated in Advanced Design System (ADS). The meander line antenna is of size 10.2*9.2mm is designed in UHF (Ultra High Frequency) band using flexible polyester substrate with a dielectric constant of 3.5. The antenna is resonating at a frequency of 862.5 MHz with a return loss of -39.133 db.

Keywords: RFID, EIRP, EPC, UHF.

I. INTRODUCTION

Now-a-days Radio Frequency Identification (RFID) tags are used in many areas. RFID has been adopted in military for monitoring and security purposes. RFID has many applications in medical field. RFIDs are also used in library for issuing books. This technology is also used for tracking of goods using EPC (Electronic Product Code).This can also be used for espionage purposes. The RFID has EPC (Electronic Product Code) which is unique. Therefore the RFID can efficiently replace the barcodes.

The back scatter method is usually deployed in the passive RFID tag because the passive RFID tag does not have a power supply. If there is power supply it will occupy more space. RFID tags need antennas for transmission. As for as RFIDs are concerned the size of the antenna should be very small when compared to the size of the antenna in other applications. The major constraint in the RFID is the size of the antenna. RFID antennas are available in various sizes and shapes. In wireless applications especially in RFID applications the size of the antenna should be of very small size. Meandering is one of the methods in order to reduce the size of the antenna. By meandering we can reduce the size of the antenna by about 70%. Meandering also provides inductive effect to the antenna which will be useful for RFID applications. The meander line antennas are used in various applications such as RFID, LTE (Long Term Evolution) etc.

The meander line antenna is a monopole antenna which is folded back and forth in order to reduce the size. Meandering the antenna saves a lot of space. It is also known as quarter wave monopole antenna. The meander line antenna is an end fed antenna. Impedance matching should be done between antenna and the chip of the RFID tag for maximum power transfer. Since the RFID tag chip exhibits capacitive impedance, the antenna should have inductive impedance. Impedance matching can be done using analytical method i.e. by using smith charts. The read range of the tag can be calculated by using Friss transmission formula.

II. RFID TRANSMISSION AND RECEPTION

A. RFID network

An aloof back-scattered RFID network works in the following way. The RFID reader transmits the signal. The RF voltage is developed on the receiving antenna terminals of the RFID tag. This voltage powers up the chip, which sends back the data by modulated backscatter method. The impedance normally switches between two unique states the conjugate match and some other impedance. It successfully sends the back-scattered signal. The block diagram of RFID is shown in fig1.

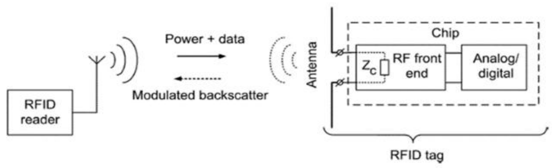

Fig.1: Block diagram of RFID Transmission

It comprises both the RFID reader and the RFID tag. Usually the RFID reader antenna is a helical antenna which uses circular polarization to transmit (power+data) a signal to the tag. The transmitted signal is received by the RFID tag antenna. Both the transmitting and the receiving antennas should use the same kind of polarization. Otherwise the signal transmitted is not received by the tag antenna.

$$PLF=\cos^2\beta \qquad (1)$$

Where the PLF is polarization loss factor and β is the angle between transmission and reception of the antenna.

The RFID tag chip comprises the RF front end block and the ADC block. The read range can be calculated using Friss free-space formula as

$$r = \frac{\lambda}{4\Pi}\sqrt{\frac{P_t G_t G_r \tau}{P_{th}}} \qquad (2)$$

Where r is the read range, λ is the wavelength, P_t is the power transmitted by the reader, G_t is the gain of the

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transmitting antenna, Gr is the gain of the receiving tag antenna, P_{th} is the minimum threshold power necessary to provide enough power to the RFID tag chip and τ is the power transmission coefficient.

B. Attributes of the meander line antenna

The meander line antennas are nothing but quarter wave monopole antennas folded back and forth. These antennas are generally end fed antennas. The resistance and reactance of the antenna can be controlled by trimming and punching techniques. The adjacent horizontal segments of the meander line antenna have an opposite phase. The transmission line current neither radiates neither power nor produce losses. If the turns are very close to each other, then cross coupling will be more which in turn affects the polarization purity of the resultant radiation pattern. The current directions are changing in every half wavelength. The radiations from the turn add up to produce the desired polarization, which depends on the dimensions of the antenna. The meander line antennas radiation pattern is omnidirectional similar to the dipole radiation pattern. The meander line antenna radiates perpendicular to its axis, i.e., the field pattern is normal to the axis of the antenna.

The resonant frequency of the antenna is dependent on 5 parameters. Number of turns of the antenna, the length of the vertical section, the length of the horizontal section, the length of the conducting line and the width of the line. As mentioned earlier, these antennas can be modelled as parasitic elements. The Meander line antenna using parasitic elements is shown in the fig.2.

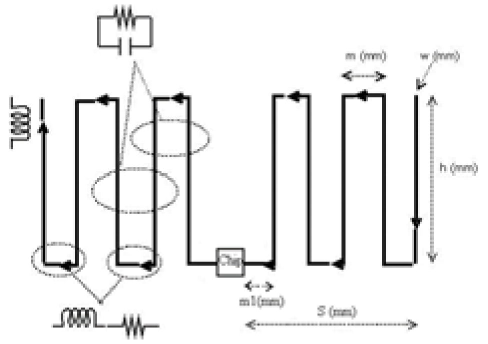

Fig.2.Meander line antenna using parasitic elements

These are converted to micro strip lines by Richard transformations and kuroads identities. According to Richard's transformation, the inductors are considered to be short circuited stubs and capacitances as open circuited stubs. The equivalent circuit of shorted terminated transmission line is shown in the fig.3

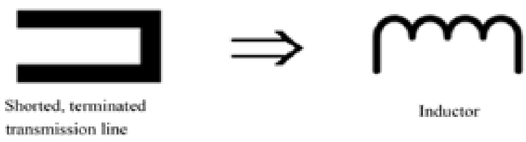

Fig.3: Equivalent circuit of shorted terminated transmission line

Transmission lines are known as all pass filters. Meander line antenna is also made up of transmission lines, but it should act like a band pass filter. It should allow certain range of frequencies. Meander line antenna can also be viewed as a coupled filter. There is mutual coupling between the two adjacent transmission lines.

In the meander line antenna the length of the patch is more than the width of the patch. The bandwidth of meander line antennas is more than the bandwidth of the patch antenna. Meander line antennas are also used for wideband applications because they can resonate at different independent frequencies. Meandering means windings or turnings. As you increase the number of turns the antenna will resonate at lower frequencies. The antenna resonance frequency depends on the size of the antenna. Due to fringing effects the size of the antenna is virtually increased. Therefore trimming should be done in order to reduce the size of the antenna. If you trim the antenna by 5mm, the resonant frequency will be shifted by about 20MHz.One more technique to shift resonant frequency is punching holes in the antenna.

III. DESIGN METHODOLOGY

The antenna is designed according to the requirement in the ADS. The application should be selected and tag requirements should be defined. The application chosen here is RFID. The materials for antenna construction have to be determined. The RF impedance of packaged ASIC should also be determined. The type of antenna and its parameters should be identified. The parametric study and optimization should be done. The prototypes Impedance matching of the tag antenna should be built and measured with the chip. The antenna has to be matched with the tag by using matching networks using smith charts.

A. Design of Meander Line Antenna

It is obvious that for the quarter wave monopole antenna, it will be λ/4.Therefore the length of the antenna is86.60mm for 866 MHz frequency.
For RFID applications the antenna size should be of very small size. It can be folded back and forth, reducing the size of the antenna. Therefore the length of the antenna is λ/32.The size of the antenna is 10.82mm.The number of turns will be around 86.60/10.82=8 turns

B. Read range calculation

The read range of the tag antenna at 866MHz is calculated. RFID passive UHF tag considered for designing has a threshold power of 50 µW, gain of 2.15 dB and EIRP (Effective Isotropic Radiated Power) of 0.825W

$$P_{rec}=P_T*G_T*G_R*\lambda^2/(4\Pi R)^2 \quad (3)$$

Where P_T is the transmitted power, G_T is the transmitter gain, G_R is the gain of the receiver.

$$=EIRP*G_R*\lambda^2/(4\Pi R)^2 \quad (4)$$

R=4.534m

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The read range of the tag antenna at 866MHz is around 4.534m.

C. Structure of the Meander line antenna in ADS

The Structure of the Meander line antenna in ADS is shown in the fig4.

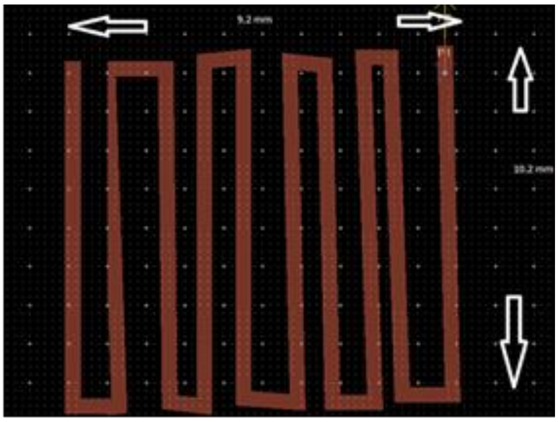

Fig.4: Structure of the Meander line antenna in ADS

The meander line antenna is simulated using the ADS software. There are two methods of simulation, i.e., the method of moments and the EMDS. The ADS generates the layout of the antenna. The antenna is designed according to the calculation. The size of the antenna is 9.2mm*10.2mm.The antenna is end fed by port1.Port2 is assigned to the substrate. It calculates the field with the FEM method. It can also be calculated with the FDTD method. The antenna traces are made up of copper. The substrate used here is flexible polyester substrate with a dielectric constant of 3.5.The dielectric loss tangent is 0.03.This antenna has 9 windings. The spaces between the turns are unequal. The antenna width is also unequal in this case. The 3D EM pre view of the meander line antenna is shown in the fig.5.

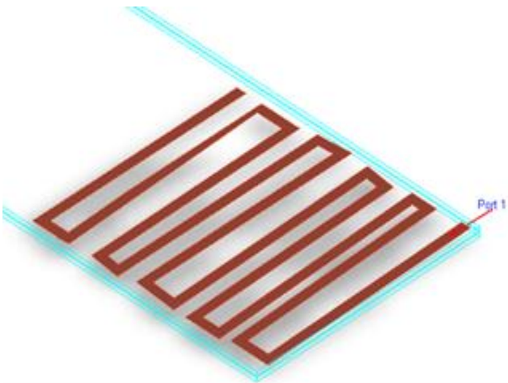

Fig.5: 3D EM per view of the meander line antenna

IV. SIMULATION RESULTS

A. Return loss

The return loss of the meander line antenna s11 is shown in the fig.6.

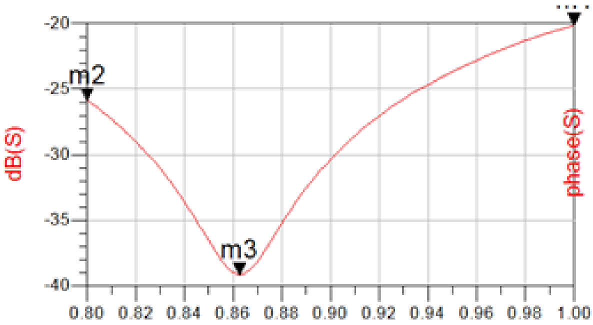

Fig.6: Return loss of the antenna

The return loss of the antenna at the resonating frequency is -39.133 db. The antenna is resonating at a frequency of 862.5 MHz. The resonating frequency is in the UHF band.

B. Smith Chart

The Smith chart for the meander line antenna is shown in the fig.7.

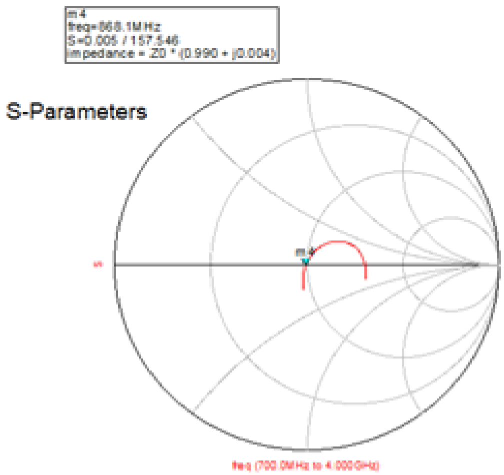

Fig.7: Smith chart for the meander line antenna

From the smith chart it is clear that the antenna is matched to 50Ω at 868.1MHz.The meander line antenna is inductive in the UHF and as well as in the microwave frequency range.

C. 3D radiation pattern

The 3D radiation pattern of the meander line antenna is shown in the fig8.

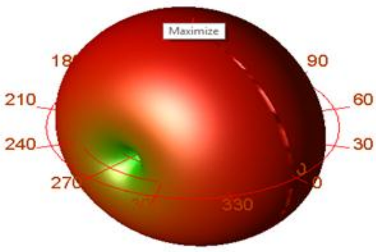

Fig.8:3D Radiation pattern of the meander line antenna

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D. Multiple resonance frequency of the antenna

The multiple resonance of the meander line antenna is shown in the fig 9.

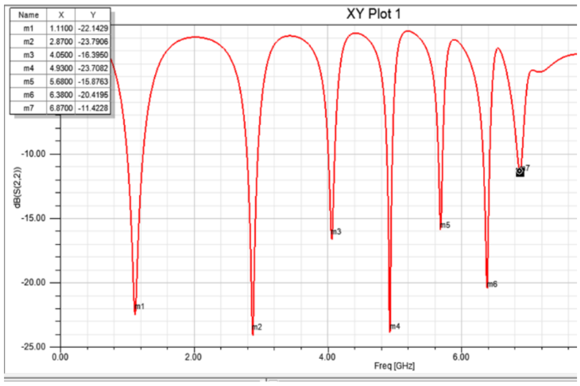

Fig.9: Multi band resonance frequency of the antenna

The meander line antenna resonates at multiple frequencies. The return loss of the antenna is less than -20db at four different frequencies 1.1GHz, 2.87GHz, 4.9GHz and 6.38GHz. Therefore the meander line antenna is a multiple resonant antenna or multi band antenna. The meander line antenna is also used for tuning purposes. Usually meander line antennas are used for wideband applications because they will resonate at different frequencies.

V.CONCLUSIONS

The designed meander line antenna is resonating at 862.5 MHz with a good return loss of -39.133db.From the 3D radiation pattern, it is clear that the meander line antenna is radiating normal to its axis. From the smith chart, it is clear that antenna is inductive in both the UHF and microwave frequency range. The meander line antenna resonates at multiple frequencies with good return loss; therefore it can be used for wideband applications.

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